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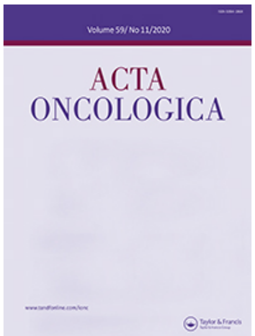

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ORIGINAL ARTICLE

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Trends in cancer survival in the Nordic countries 1990–2016: the NORDCAN survival studies

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ABSTRACT

Background: Differences in cancer survival between the Nordic countries have previously been reported. The aim of this study was to examine whether these differences in outcome remain, based on updated information from five national cancer registers.
Materials and methods: The data used for the analysis was from the NORDCAN database focusing on nine common cancers diagnosed 1990–2016 in Denmark, Finland, Iceland, Norway and Sweden with maximum follow-up through 2017. Relative survival (RS) was estimated at 1 and 5 years using flexible parametric RS models, and percentage point differences between the earliest and latest years available were calculated.
Results: A consistent improvement in both 1- and 5-year RS was found for most studied sites across all countries. Previously observed differences between the countries have been attenuated. The improvements were particularly pronounced in Denmark that now has cancer survival similar to the other Nordic countries.
Conclusion: The reasons for the observed improvements in cancer survival are likely multifactorial, including earlier diagnosis, improved treatment options, implementation of national cancer plans, uniform national cancer care guidelines and standardized patient pathways. The previous survival disadvantage in Denmark is no longer present for most sites. Continuous monitoring of cancer survival is of importance to assess the impact of changes in policies and the effectiveness of health care systems.

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Cancer survival; comparison; Nordic cancer registries; NORDCAN

Introduction

Marked differences in cancer incidence and survival between countries and jurisdictions have been documented in several reports, as well as differences in temporal trends across countries and calendar time [1–4]. A series of 13 articles published in 2010 comparing time trends in cancer incidence and outcomes in the five Nordic countries 1964–2003 (https://www.ancr.nu/cancer-data/cancer-survival/acta-oncologica-2010) confirmed earlier findings of both similarities and differences in cancer survival, with notable poorer outcomes observed in Denmark. At that time, one conclusion was that cancer plans initiated in Denmark in 2000 and in Norway in 1997, appeared to not yet have had an impact on cancer incidence, mortality or survival [5]. A more recent study which compared cancer survival in Europe 1999–2007, EUROCARE-5, also reported a survival disadvantage in Danish patients [3].

With more than 10 years of additional data available, it is now possible to investigate if concerted national efforts to improve early detection and quality of cancer care have had detectable effects, and if differences in cancer survival between the Nordic countries still persist. Since the 2010 comprehensive Nordic comparison, efforts to improve cancer care have been made in each Nordic country. These efforts include implementing and updating national cancer plans and guidelines, changes in screening programs, centralization of cancer treatment, accelerated cancer patient pathways and improved access to new cancer therapies.

This study utilizes data on nine common cancers diagnosed between 1990 and 2016 from the NORDCAN database [6], which is a collaboration between the cancer registries of

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Supplemental data for this article can be accessed here.

Denmark, Finland, Iceland, Norway and Sweden [7]. Summary incidence, mortality and survival figures from NORDCAN are published online [8]. The aim of this Nordic collaborative study is three-fold. First, to study possible changes in both short and long-term survival over this time period by estimating overall and conditional cancer survival. Second, to investigate whether previously observed differences in cancer survival between the Nordic countries remain. Third, to put these results into context, we also present trends in cancer incidence and mortality.

Methods

Data

We obtained individual-level data for nine common cancer from Denmark, Finland, Iceland, Norway and Sweden from the NORDCAN database, which includes information from the national cancer registries in each country [6–8]. All individuals diagnosed with the following cancers between 1990 and 2016 were included: primary cancers of the colon (including appendix, International Classification of Diseases version 10 [ICD10]: C18), rectum (C19–C20), lung and trachea (C33–C34), malignant melanoma of skin (C43), kidney (C64), breast (C50), uterus (corpus uteri, C54), ovary (including fallopian tubes and uterine ligaments, C56–C57.4) and prostate (C61). Follow-up for death and emigration was to the end of 2017 for all countries, except for Finland where follow-up ended in 2016. Emigration information was unavailable for Iceland.

We excluded cases diagnosed only on the basis of a death certificate (DCO) or through incidental autopsy findings. We also excluded childhood cancers (patients aged <18 years at diagnosis), breast cancer in men and subsequent primary tumors at the same site in the same patient (Supplementary Table 1).

Population-based expected mortality rates in each country, stratified by age, sex and calendar year were obtained from each country's national statistics office.

Statistical analysis

We estimated marginal relative survival (RS) to quantify survival in the absence of death from other causes. We present 1-year and 5-year RS, and 5-year RS conditional on survival to 1-year post-diagnosis for women and men, across countries and calendar time. We adopted a modeling approach to estimate RS using flexible parametric RS models fitting separate models to each cancer site for each country. The models incorporated age at diagnosis, calendar year and sex (for relevant sites). After fitting the model, age-standardized estimates of RS were obtained using regression standardization stratified by calendar year and sex [9]. We used an adapted version of the International Cancer Survival Standard 1 (ICSS1) age-standard weights for all cancer sites by 10-year age groups, except for melanoma where the adapted ICSS2 weights were used (Supplementary Table 2).

Flexible parametric RS models use restricted cubic splines to model the baseline excess hazard over time since diagnosis [10,11]. The models incorporate the expected mortality rates for each country. In the analyses, 5 degrees of freedom (df) were used to model the log cumulative baseline excess hazard with sex as a binary covariate. Age and calendar year at diagnosis were included as continuous variables allowing for non-linear effects by using restricted cubic splines with 3 df. Two-way interactions between age and calendar year, age and sex, and calendar year and sex were included. The proportional excess hazards assumption was relaxed by incorporating time-dependent effects for calendar year, age, sex, and their interaction terms (three-way interactions), with 3 df for each time-dependent effect.

Due to the small population size, simpler models were used for Iceland. These excluded the three-way interactions and used 2 df for time-dependent effects. For cancers of the uterus, ovary and melanoma in Iceland, there were few cancer cases and/or deaths. For that reason a modeling approach was not adopted and estimates were obtained using the non-parametric Pohar Perme approach in 5-year groups of calendar year at diagnosis [12], incorporating relative weights [13]. To improve model stability for the very young and elderly, 96% of the age distribution was modeled continuously while individuals outside the 2nd and 98th percentile of age had their age reassigned to those percentile limits and were assumed to have the same RS (i.e. winsorizing) [14]. As a validation of our models, we compared the parametric estimates to Pohar Perme estimates and found them to be in good agreement.

Absolute survival differences, as measured by percentage point (pp) differences in 5-year RS between 1990 and 2010, and 1-year RS between 1990 and 2015, were estimated with 95% confidence intervals (CI) from the models. The corresponding differences for cancers of the uterus, ovary and melanoma in Iceland were calculated from the latest and earliest non-parametric estimates.

As improvements in 5-year survival often reflect improvements in early survival (e.g. within a year of diagnosis), the 5-year RS conditional on surviving 1 year captures the 1–5 year survival experience of the patients. This is important in order to disentangle the early and later survival improvements over the first 5 years since diagnosis.

In addition to modeling trends over time, a period analysis model was used to obtain up-to-date estimates where only follow-up time during a period window was included in the analysis. The period window was 2013–2017 for Denmark, Norway, Sweden, 2012–2017 for Iceland and 2013–2016 for Finland. These models were essentially the same as above, without the need to incorporate calendar year. For melanoma in Denmark and kidney cancer in Norway, the models were simplified by using 2 df for time-dependent effects due to convergence issues. Non-parametric estimates were calculated for cancers of the uterus, ovary and melanoma in Iceland.

Incidence and mortality rates were estimated using 3-year diagnoses windows. Rates were age standardized using the Nordic population distribution in the year 2000 (Supplementary Table 3).

All the analyses were performed in Stata/IC 16.0 (StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC). The commands `stpm2` and `standsurv` were used for obtaining parametric estimates, and `strs` for non-parametric estimates [15,16].

Ethical approval for this study was granted by the Swedish Ethical Review Authority (ethical approval 2017/641-31/1, amendment 2019-01913) and study permission from the National Institute of Health and Welfare in Finland (approval THL/870/5.05.00/2014, amendment 2019).

Results

In total, the cohorts from the five Nordic countries included 1,032,846 cancers in women and 1,006,836 cancers in men for nine tumor sites diagnosed between 1990 and 2016. The number of cases and exclusions by sex, site and country are presented in Supplementary Table 1. Breast, lung and colon cancer were the three most common sites among women, while prostate, lung and colon cancer were the most common sites among men.

Colon cancer

Period estimates of 5-year RS for colon cancer ranged from 62% (Iceland) to 69% (Norway) in women and from 63% (Sweden) to 67% (Denmark) in men (Table 1). Survival improved over the study period in all Nordic countries for both women (Figure 1(a)) and men (Figure 1(b)). The lower 1- and 5-year RS in Denmark in the early 1990s improved over time and was in line with the other Nordic countries at the end of the study period. The change in 5-year RS between 1990 and 2010 was +16 pp in Danish women and +17 pp in men (Table 2). There was also an improvement in 5-year RS conditional on survival 1-year in both women and men (Figure 2). The incidence of colon cancer increased in both sexes over the study period, while there was a slight decrease in mortality (Supplementary Figure 1a and 1b).

Rectal cancer

For rectal cancer, the period estimates of 5-year RS ranged from 68% (Sweden) to 78% (Iceland) in women and between 65% (Finland, Sweden) and 69% (Denmark, Norway) in men (Table 1). Survival improved in all Nordic countries for both women (Figure 1(a)) and men (Figure 1(b)), with particularly pronounced improvements in women in Denmark and Iceland. The change in 5-year RS was +28 pp in Icelandic women and +22 pp in both Danish women and men from 1990 to 2010 (Table 2). There was also an improvement in 5-year RS conditional on surviving 1 year in both women and men (Figure 2). During the period under study, the rectal cancer incidence remained constant in both sexes, while mortality decreased (Supplementary Figure 1a and 1b).

Lung cancer

Among individuals with lung cancer, the period estimates of 5-year RS ranged from 19% (Finland) to 26% (Iceland, Norway) in women and between 13% (Finland) and 20% (Iceland) in men (Table 1). One-year RS improved markedly over the study period in all countries for both women (Figure 1(a)) and men (Figure 1(b)), in particular in the 2000s. The change in 1-year RS from 1990 to 2015 was +30 pp in Danish, +25 pp in Swedish and +22 pp in Norwegian women, while in men the corresponding numbers were +23 pp, +20 pp and +18 pp (Table 2). Improvements in 1-year RS were less pronounced in Finland (+12 pp in women and +5 pp in men) and Iceland (+19 pp in women and +12 pp in men) (Table 2). In all Nordic countries, improvements in 1-year RS were more marked than improvement in 5-year RS. There was, however, an improvement in 5-year RS conditional on survival 1 year in both women and men, especially after 2005 (Figure 2). Lung cancer incidence and mortality in

Table 1. Period estimates of 5-year relative survival with 95% confidence intervals, by sex, site and country in the latest available 5-year period, the NORDCAN survival studies.

Site	ICD-10	Denmark	Finland	Iceland	Norway	Sweden
Women						
Colon	C18	68 (67–69)	68 (66–70)	62 (57–68)	69 (68–71)	65 (64–67)
Rectum	C19–C20	71 (70–73)	69 (67–72)	78 (70–88)	71 (69–73)	68 (66–69)
Lung	C33–C34	23 (22–24)	19 (17–20)	26 (22–31)	26 (25–27)	24 (23–25)
Melanoma	C43	95 (94–96)	94 (93–95)	97 (87–99)[a]	93 (92–94)	94 (94–95)
Kidney	C64	69 (66–72)	68 (66–71)	73 (64–82)	75 (72–78)	75 (73–78)
Breast	C50	87 (87–88)	90 (90–91)	87 (84–90)	89 (88–90)	90 (89–90)
Uterus	C54	82 (81–84)	84 (82–85)	84 (73–91)[a]	84 (83–86)	84 (83–85)
Ovary	C56–C57.4	42 (40–44)	44 (42–46)	46 (35–56)[a]	47 (45–50)	51 (49–52)
Men						
Colon	C18	67 (65–68)	66 (64–68)	66 (60–72)	65 (64–67)	63 (62–65)
Rectum	C19–C20	69 (67–71)	65 (63–67)	67 (59–76)	69 (68–71)	65 (64–66)
Lung	C33–C34	17 (16–18)	13 (12–14)	20 (17–25)	19 (18–20)	19 (18–20)
Melanoma	C43	91 (90–92)	87 (86–89)	86 (76–91)[a]	87 (86–89)	91 (90–92)
Kidney	C64	67 (65–69)	65 (62–67)	65 (58–73)	72 (70–74)	74 (72–76)
Prostate	C61	87 (86–87)	94 (93–95)	89 (86–91)	93 (92–94)	91 (91–92)

Follow-up window for Denmark, Norway and Sweden: 2013–2017; Finland: 2013–2016; Iceland: 2012–2017.
[a]Age-standardized Pohar Perme estimates over 5-year intervals of calendar year.

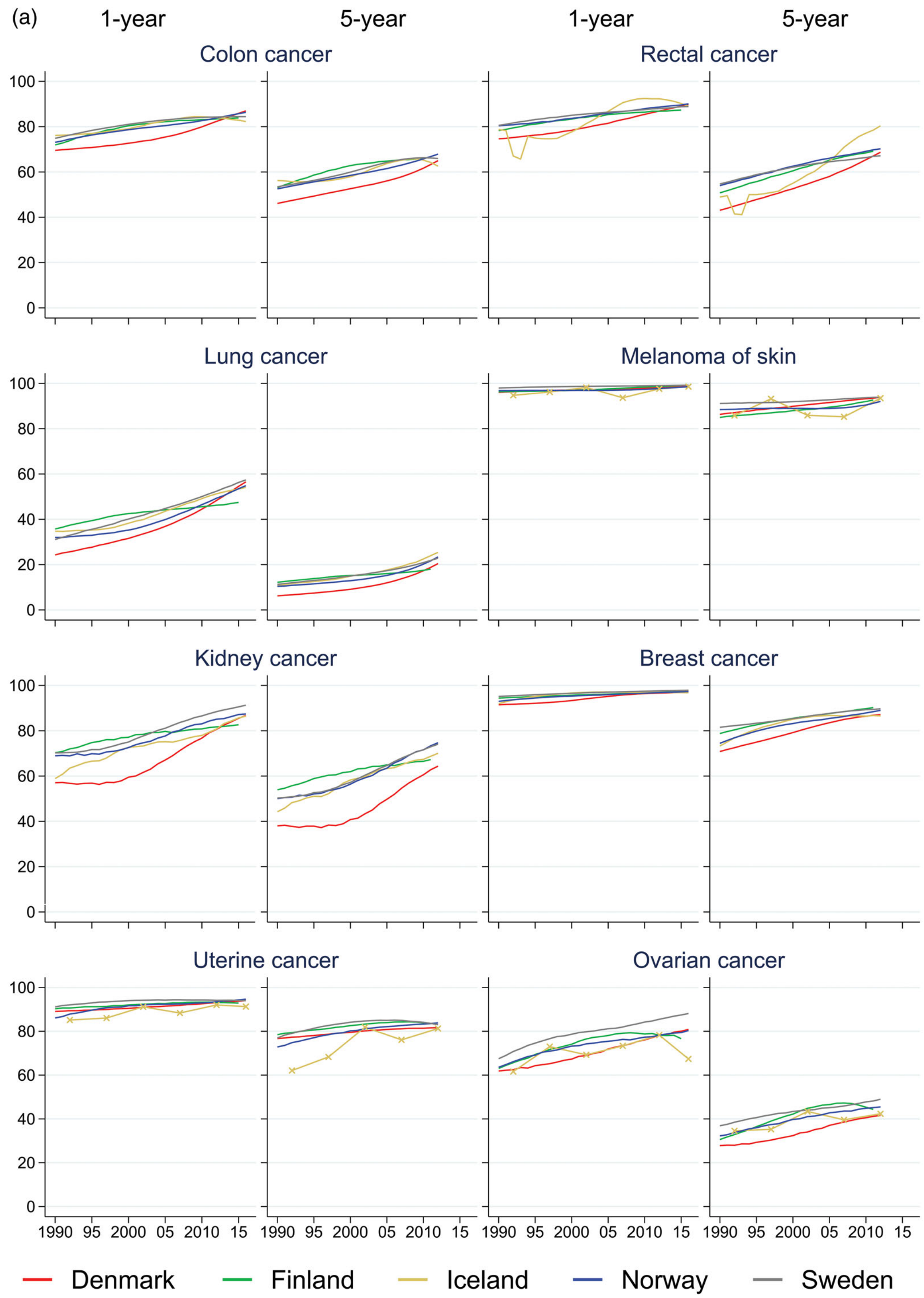

Figure 1. (a) Trends over time in 1- and 5-year relative survival 1990–2016, women, the NORDCAN survival studies. Age-standardized Pohar Perme estimates over 5-year intervals of calendar year presented for melanoma, ovarian and uterine cancer in Iceland. Crosses mark the center of each interval. (b) Trends over time in 1- and 5-year relative survival 1990–2016, men, the NORDCAN survival studies. Age-standardized Pohar Perme estimates over 5-year intervals of calendar year presented for melanoma in Iceland. Crosses mark the center of each interval.

women increased over time while decreasing in men (Supplementary Figure 1a and 1b).

Melanoma of skin

For melanoma, the period estimates of 5-year RS ranged from 93% (Norway) to 97% (Iceland) in women and from 86% (Iceland) to 91% (Denmark, Sweden) in men (Table 1). Despite high survival in the 1990s, further improvements were observed in both men and women in all countries (Figure 1(a,b)). There was also improvement in 5-year RS conditional on surviving 1 year (Figure 2). There was a rapid increase in the melanoma incidence in both sexes in all countries (except Iceland where incidence has decreased in the later years). The mortality remained fairly stable with the

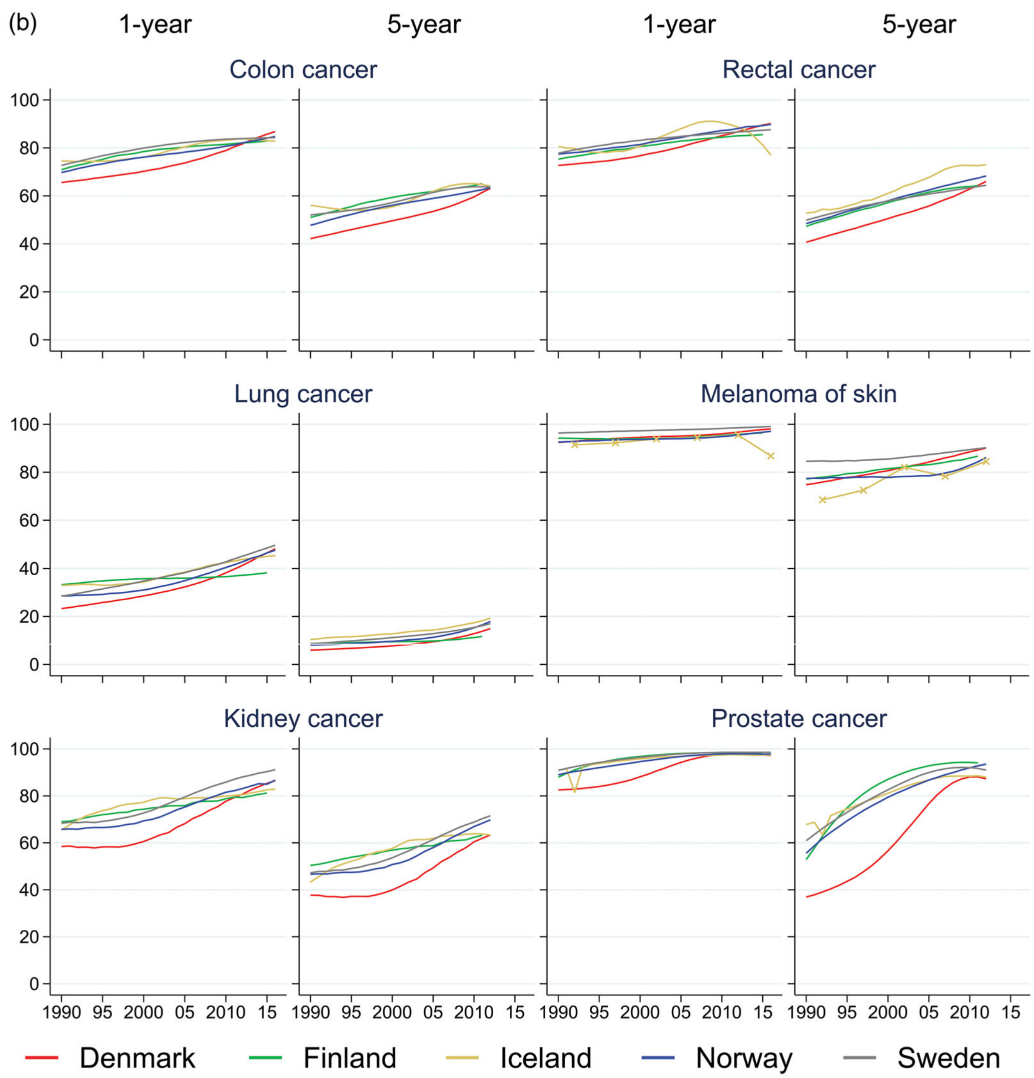

Figure 1. (Continued).

exception of Norway, where there was a slight increase (Supplementary Figure 1a and 1b).

Kidney cancer

For kidney cancer, the period estimates of 5-year RS ranged from 68% (Finland) to 75% (Norway, Sweden) in women and between 65% (Finland, Iceland) and 74% (Sweden) in men (Table 1). Survival improved in all Nordic countries for both women (Figure 1(a)) and men (Figure 1(b)), in particular for Denmark, but less so for Finland. The change in 5-year RS from 1990 to 2010 was just over 20–23 pp in both women and men in all countries except in Finland where the change was +13 pp (women) and +12 pp (men) (Table 2). The improvement in 5-year RS conditional on surviving 1 year was the largest in Denmark for both women and men (Figure 2). The incidence of kidney cancer was mainly stable over the study period and countries in women, while the incidence increased in Danish and Norwegian men (Supplementary Figure 1a and 1b). Mortality decreased somewhat in all countries.

Breast cancer

For breast cancer, the period estimates of 5-year RS estimates ranged from 87% (Denmark, Iceland) to 90% (Finland, Sweden) (Table 1). During the study period, both 1- and 5-year RS improved in all countries (Figure 1(a)), in particular in Denmark with *a* + 16 pp change in 5-year RS from 1990 to 2010 (Table 2). Improvements were also observed in 5-year RS conditional on surviving 1 year (Figure 2). Breast cancer incidence increased in all countries, with the highest incidence in Denmark and lowest in Norway, while mortality decreased (Supplementary Figure 1a).

Uterine cancer

For uterine cancer, the period estimates of 5-year RS estimates ranged from 82% (Denmark) to 84% (Finland, Iceland, Norway, Sweden) (Table 1). In all countries, there were only small improvements in both 1- and 5-year RS over the study period (Figure 1(a)), with the largest increase in Iceland. The change in 5-year RS ranged from +5 to +19 pp across

Table 2. Percentage point change in 1- and 5-year relative survival since 1990 with 95% confidence intervals, by sex, site and country, the NORDCAN survival studies.

Site	Denmark	Finland	Iceland	Norway	Sweden
Change in 1-year relative survival between 1990 and 2015					
Women					
Colon	16 (15 to 18)	12 (10 to 14)	7 (−2 to 15)	13 (11 to 14)	10 (8 to 11)
Rectum	14 (12 to 17)	9 (6 to 12)	11 (0 to 23)	9 (7 to 11)	8 (6 to 10)
Lung	30 (29 to 32)	12 (9 to 14)	19 (11 to 26)	22 (19 to 24)	25 (23 to 27)
Melanoma	3 (2 to 4)	3 (1 to 4)	4 (−3 to 11)[a]	2 (1 to 2)	1 (1 to 2)
Kidney	28 (25 to 32)	12 (9 to 16)	27 (11 to 43)	18 (15 to 22)	20 (18 to 23)
Breast	5 (5 to 6)	3 (2 to 4)	5 (1 to 9)	4 (3 to 5)	3 (2 to 3)
Uterus	5 (3 to 7)	3 (1 to 5)	6 (-5 to 18)[a]	8 (6 to 10)	3 (2 to 4)
Ovary	18 (15 to 21)	14 (11 to 17)	6 (-14 to 25)[a]	16 (13 to 19)	20 (18 to 22)
Men					
Colon	20 (18 to 22)	12 (9 to 14)	8 (0 to 17)	14 (12 to 16)	12 (10 to 13)
Rectum	17 (15 to 19)	10 (8 to 13)	1 (−12 to 13)	12 (10 to 14)	10 (8 to 11)
Lung	23 (22 to 24)	5 (3 to 7)	12 (5 to 19)	18 (16 to 20)	20 (18 to 21)
Melanoma	5 (4 to 7)	2 (0 to 4)	−5 (−19 to 10)[a]	4 (3 to 6)	3 (2 to 3)
Kidney	27 (23 to 30)	12 (9 to 16)	17 (4 to 30)	19 (16 to 23)	22 (19 to 25)
Prostate	15 (13 to 17)	10 (9 to 12)	6 (2 to 11)	9 (7 to 10)	8 (7 to 9)
Change in 5-year relative survival between 1990 and 2010					
Women					
Colon	16 (13 to 18)	13 (10 to 16)	9 (−2 to 20)	13 (11 to 15)	13 (11 to 15)
Rectum	22 (19 to 25)	18 (14 to 21)	28 (12 to 44)	15 (12 to 18)	12 (9 to 14)
Lung	11 (10 to 12)	5 (3 to 7)	12 (7 to 16)	10 (8 to 11)	10 (8 to 11)
Melanoma	7 (5 to 9)	7 (4 to 10)	8 (-5 to 21)[b]	2 (0 to 4)	3 (1 to 4)
Kidney	23 (18 to 27)	13 (9 to 16)	23 (6 to 40)	22 (17 to 26)	21 (18 to 25)
Breast	16 (14 to 17)	11 (9 to 12)	13 (6 to 20)	13 (12 to 15)	8 (7 to 9)
Uterus	5 (2 to 7)	5 (3 to 8)	19 (1 to 37)[b]	10 (7 to 13)	7 (5 to 9)
Ovary	13 (10 to 15)	15 (12 to 18)	8 (−8 to 24)[b]	13 (10 to 15)	11 (9 to 13)
Men					
Colon	17 (15 to 20)	13 (10 to 17)	9 (−3 to 21)	14 (12 to 17)	12 (10 to 14)
Rectum	22 (20 to 25)	17 (13 to 20)	20 (1 to 39)	18 (15 to 21)	14 (11 to 16)
Lung	7 (6 to 8)	2 (1 to 4)	7 (2 to 12)	7 (6 to 8)	7 (6 to 8)
Melanoma	14 (11 to 17)	9 (5 to 12)	16 (−7 to 39)[b]	5 (3 to 8)	5 (3 to 7)
Kidney	23 (19 to 27)	12 (8 to 16)	21 (7 to 34)	20 (16 to 24)	22 (19 to 25)
Prostate	51 (49 to 53)	41 (39 to 44)	21 (12 to 29)	36 (34 to 39)	31 (30 to 33)

[a]Based on age-standardized Pohar Perme estimates from diagnosis years 1990–1994 and 2015–2016.
[b]Based on age-standardized Pohar Perme estimates from diagnosis years 1990–1994 and 2010–2014.

countries from 1990 to 2010 (Table 2). The incidence trend of uterine cancer varied between countries, with an increase in Norway and only minor increases in the other countries (Supplementary Figure 1a). While mortality remained stable in Finland, Sweden and Iceland, there was evidence of a decrease in Denmark and Norway (Supplementary Figure 1a).

Ovarian cancer

For ovarian cancer, the period estimates of 5-year RS estimates ranged from 42% (Denmark) to 51% (Sweden) (Table 1). Over the study period, both 1- and 5-year RS improved in all countries (Figure 1(a)). The change in 1-year RS from 1990 to 2015 was +7 pp in Iceland and ranged from +14 pp to +20 pp in the other countries (Table 2). The change in 5-year RS varied between +8 pp (Iceland) and +15 pp (Finland) (Table 2). The improvements in 5-year RS conditional on surviving 1 year were less pronounced (Figure 2). The incidence and mortality of ovarian cancer decreased in all Nordic countries (Supplementary Figure 1a).

Prostate cancer

For prostate cancer, the period estimates of 5-year RS estimates ranged from 87% (Denmark) to 94% (Finland) (Table 1). Both 1- and 5-year RS improved in all Nordic countries (Figure 1(b)), in particular in Denmark where the improvement was most pronounced for men diagnosed between 2000 and 2010. The change in 1- and 5-year RS was +15 pp and +51 pp, respectively, in Danish men from 1990 to 2015/2010 (Table 2). Similar patterns of improvement were also observed in 5-year RS conditional on surviving 1 year (Figure 2). Prostate cancer incidence increased in all countries, although the increase in Denmark occurred later. Prostate cancer mortality decreased across all countries (Supplementary Figure 1b).

Point estimates of 1- and 5-year RS for every 5th calendar year, with 95% confidence intervals, are presented in Supplementary Tables 4 and 5. The corresponding estimates of 5-year RS conditional on surviving 1 year after diagnosis are presented in Supplementary Table 6.

Discussion

Including more than 2 million men and women diagnosed with cancer, we found general and consistent improvements in both short- and long-term cancer survival across nine major cancer sites in the Nordic countries between 1990 and 2017. The previously observed survival disadvantage in Denmark up until 2006 [5] is no longer present for most sites, with improvements in both 1-year and 5-year survival. Although the survival trends in general are consistent over the Nordic countries, an exception is in Finland where lung and kidney cancer survival has improved less over time.

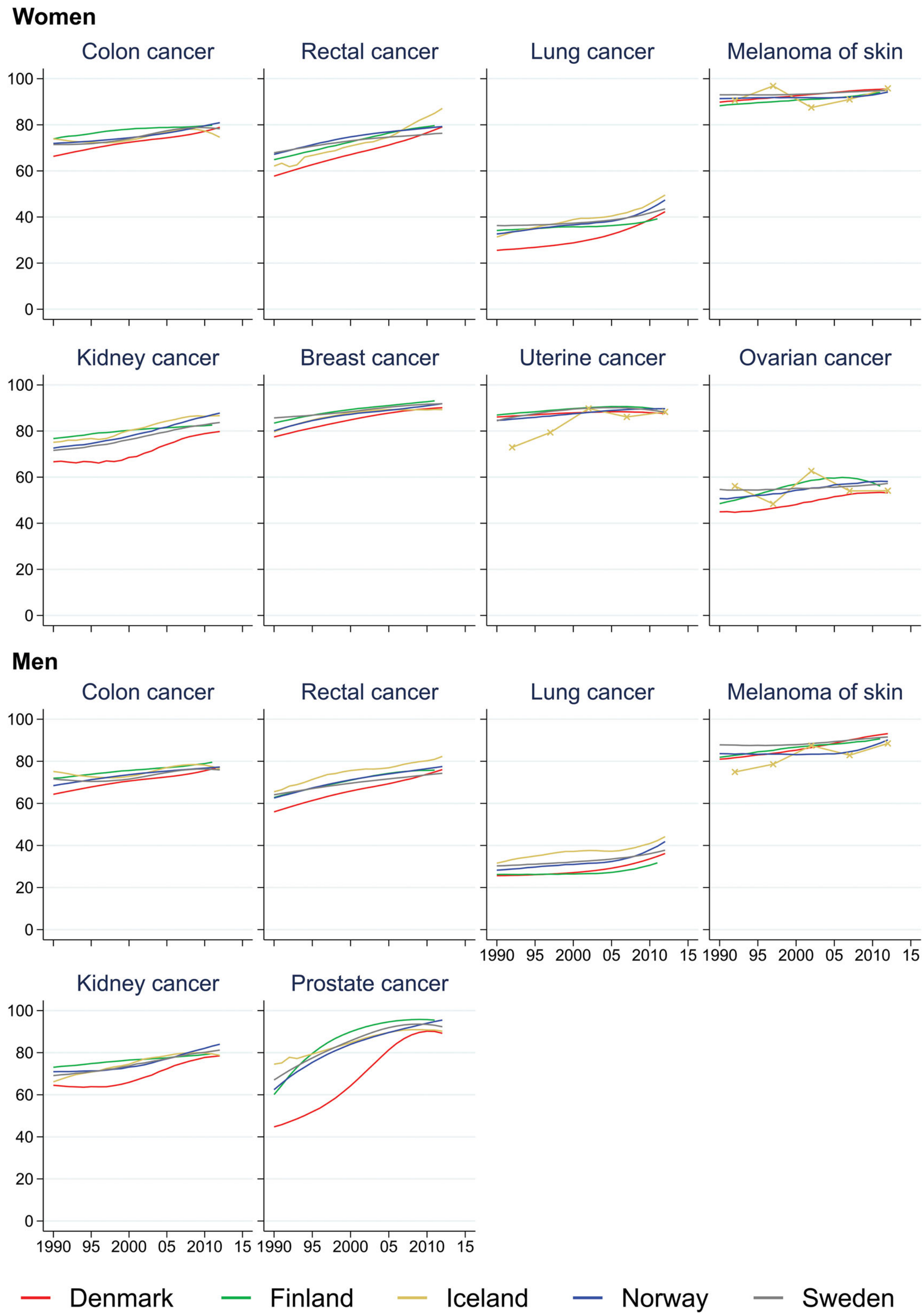

Figure 2. Trends in 5-year relative survival conditional on surviving 1 year, 1990–2012, the NORDCAN survival studies. Age-standardized Pohar Perme estimates over 5-year intervals of calendar year presented for melanoma, uterine and ovarian cancer in Iceland. Crosses mark the center of each interval.

Reasons for the observed improvement in cancer survival are likely to be multifactorial involving major changes over the last 30 years not only in diagnostic and treatment options, but also in policies and resource allocation. Similar improvements have also been seen in countries outside the Nordic region [1,2]. From the early 2000s, national cancer plans or strategies were implemented in the Nordic countries aiming to improve early detection and delivery of cancer care, starting in Denmark (2000), in Norway (2006), Sweden (2011) and very recently in Iceland (2019). Similar efforts have been undertaken in Finland. The national cancer plans have been developed with a focus on the patient perspective and include components such as uniform national cancer care guidelines, contact nurses, multidisciplinary treatment decisions, individualized management plans, centralization of treatment to fewer central, structured care processes and standardized pathways aiming to reduce waiting times.

Other recent changes include the introduction of new diagnostic methods allowing for targeted treatments, new oncological treatments and refined surgical techniques. Novel diagnostic tools have led not only to more precise tumor characterization and staging, but also to an increased incidence of early stage tumors and incidental findings [17]. There have also been efforts to improve early detection by public campaigns to increase awareness of signs and symptoms of cancer, implementation of organized colorectal cancer screening and increased participation in existing screening programs for breast cancer (Supplementary Table 7).

The improvements in cancer survival were particularly pronounced in Denmark that now has a cancer survival similar to the other Nordic countries. Denmark was the first Nordic country to launch a national cancer plan in 2000 followed by several updates, including a 2007 policy decision to designate cancer as an acute life-threatening disease with a focus on accelerated cancer patient pathways to reduce waiting times. Denmark was early in implementing accelerated cancer pathways 2007–2009 [18]. Changes in Denmark have also included structural reforms with healthcare provided by five administrative healthcare regions from 2007 and marked increases in health care expenditures including earmarked investments in resources for cancer care, for example computed tomography (CT) and radiation therapy.

It is also possible that changes over time in comorbidity burden and life-style factors such as smoking could have played a role for the marked improvements observed in Denmark. Smoking is associated with a higher comorbidity burden, which in turn may affect cancer treatment options and survival. Smoking prevalence has historically been high in Denmark, but has decreased markedly over time and is since the end of 1990s more similar to the other Nordic countries [5].

Although there have been general improvements in survival across sites, there are some exceptions. It is unclear why the improvement in survival for lung and kidney cancer was less pronounced in Finland than in the other countries. The observed differences in both 1-year and 5-year conditional survival could reflect varying diagnostic pathways and routines. There are observed differences in treatment protocols and patient pathways, implementation and frequency of updates of lung cancer related national guidelines and smoking cessation advice between the Nordic countries [19]. However, it is important to investigate further why improvements in survival have been less pronounced in Finland and if there are for example differences in lung cancer subtypes between countries.

The substantial improvement observed for prostate cancer survival is likely to be partly explained by an increased use of prostate-specific antigen (PSA) testing (which is also reflected in a corresponding sharp increase in prostate cancer incidence), in addition to more men receiving treatment with curative intent. Although routine PSA testing now is discouraged in all Nordic countries, testing of asymptomatic men is still performed at a varying degree at patients' request.

The incidence of melanoma of the skin has increased rapidly in both men and women in all Nordic countries with the exception of Iceland was the incidence has decreased, possibly as an effect of awareness campaigns and regulations for use of sunbeds introduced in 2003 [20]. There has been no corresponding increase in melanoma mortality, suggesting that the increase in incidence reflects the detection of early stage melanomas.

The Nordic countries have a population of over 27 million with low out-of-pocket-cost care available to all residents *via* similar tax-funded national healthcare systems. The NORDCAN database collaboration has facilitated data collection, reporting and coding practices of cancer cases. The NORDCAN database is population-based, mature and essentially complete including more than 2 million cancer patients and represents an important resource for cancer comparisons. Complete follow-up for death and migration is provided by record linkages to the Total Population Registers in each country except Iceland where migration information is unavailable. Also, traceback systems to supplement information on the time of diagnosis on cancers with only death certificate notifications to the cancer registry is undertaken in all Nordic countries except Sweden [7]. For many cancer sites, non-inclusion of death certificate initiated cases (DCI) will lead to a slight overestimation of survival, whereas including these cases will slightly underestimate survival [21]. Taken together, these biases could impact the comparisons of survival between countries, in particular for cancer sites with short survival time, such as lung cancer, or in the elderly. Limitations of our study also include the low numbers for some cancer sites, particularly for Iceland, and 1 year less follow-up in Finland.

Conclusions

There have been general improvements in cancer survival across nine major cancer sites in the Nordic countries. Although some differences in cancer survival remain, previously observed marked differences between countries have been attenuated over time. Of special note is that the previous survival disadvantage in Denmark is no longer present for most sites. The reasons for these improvements are multifactorial, including concerted efforts to improve cancer care by means of national cancer plans, earlier diagnosis and improvements in treatment. Cancer registration is essential to continue monitoring cancer survival and assess the impact of changes in policies and quality of care. In addition, data from cancer registers enable quantification and understanding of national as well as international trends and differences in cancer survival, incidence, and mortality. With the increasing availability and completeness of treatment and disease-specific information (e.g. stage and histological subtype), more detailed comparisons will be possible to further improve the understanding of the reasons for survival differences between countries.

Disclosure statement

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